ESTIMATING U.S. CONSUMER BEEF DEMAND

DIFFERENTIATED BY USDA QUALITY GRADES

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A Thesis

Presented to

The Faculty of the Graduate School

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In Partial Fulfillment

Of the Requirements for the Degree

Master of Science

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by

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The undersigned, appointed by the Dean of the Graduate School, have examined the

thesis entitled

ESTIMATING U.S. CONSUMER BEEF DEMAND

DIFFERENTIATED BY USDA QUALITY GRADES

Presented by Jillian G. Steiner

A candidate for the degree Master of Science

And hereby certify that in their opinion it is worthy of acceptance

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF DEFINITIONS

Artificial Insemination (AI) – Artificial insemination is the process of collecting bull semen and manually depositing it in the reproductive tracts of heifers or cows

Beef Quality – Throughout this study, beef quality is defined by beef sensory characteristics such as flavor, color, tenderness, and juiciness. Levels of beef quality are indicated by beef quality grades.

Beef Quality Grade – Beef quality grades are determined by the composite evaluation of factors that affect palatability including carcass maturity, firmness, texture, color of lean, and marbling. Existing U.S. Department of Agriculture quality grades include Prime, Choice, Select, Standard, Commercial, and Utility.

Carcass Maturity – The approximate live age of an animal determined by skeletal ossification and color and texture of lean. "A" maturity stands for 9 to 30 months old, "B" maturity stands for 30 to 42 months old, "C" maturity stands for 42 to 72 months old, "D" maturity stands for 72 to 96 months old, and "E" maturity stands for greater than 96 months old.

Choice – Choice is the second highest beef quality grade. To grade choice, a beef carcass must have a moderate, modest, or small degree of marbling and be of "A" or "B" maturity.

Cross-Price Elasticity – A cross-price elasticity measures the sensitivity of quantity to a change in the price of a substitute.

Demand – Demand is an economic principle describing consumers' desire and willingness to pay for a good or service.

Elasticity – An elasticity is a measure of the sensitivity of one variable to changes in another.

Estrous Synchronization – Estrous Synchronization is a reproductive management tool. Protocols are designed to control estrus and ovulation in cycling females in order to shorten the breeding season

Expected Progeny Differences (EPDs) – Expected Progeny Differences are the predictions of how future progeny of a given animal will perform relative to the progeny of other animals.

Income Elasticity – Income elasticity measures the sensitivity of quantity to a change in income, calculated as the percentage change in quantity divided by the percentage change in income.

Marbling – Marbling is fat within the muscle. Degrees of marbling include abundant, moderately abundant, slightly abundant, moderate, modest, small, slight, traces, and practically devoid.

Own-Price Elasticity – Own-price elasticity measures the sensitivity of quantity to a change in a good's own price.

Price Elasticity – Price elasticity measures the sensitivity of quantity to a change in price, calculated as the percentage change in quantity divided by the percentage change in price.

Price Flexibility – Price flexibility measures the sensitivity of price to a change in quantity, calculated as the percentage change in price divided by the percentage change in quantity.

Prime – Prime is the highest beef quality grade. To grade prime, a beef carcass must have abundant, moderately abundant, or slightly abundant marbling and be of "A" or "B" maturity.

Select – Select is the third highest beef quality grade. To grade select, a beef carcass must have slight marbling and be of "A" maturity.

Supply – Supply is determined by the amount of a good or service available to consumers.

ABSTRACT

A historically low U.S. cattle inventory combined with record cattle prices create potential for herd expansion. Many in the livestock industry are discussing the need to restructure beef production and debating over what the correct strategy might be to sustain and continue building beef demand as the industry moves forward. Schroeder, Tonsor, and Mintert (2013) identified beef quality as an important and feasibly influenced driver of consumer beef demand. However, few studies have done research on beef demand disaggregated by quality type.

The objective of this study is to provide empirical estimates of demand elasticities for beef quality types including USDA Prime, USDA Choice/Branded, and USDA Select beef by means of OLS regression procedures. This approach allows for comparison of these estimated elasticities to help determine the best production focus for the future of the beef industry.

Estimation results show Prime beef to be the most own-price elastic (-2.33) which suggests a change in the Prime quantity supplied will elicit a smaller change in price premiums. Additionally, Select beef is found to be the most sensitive to changes in the prices of competing meats. Finally, a trend term suggest there are additional factors other than those explicitly included in the model that are increasing demand for higher quality beef which could have positive implications for the future of the beef industry.

Given these results, an increased focus on beef quality appears to be a viable plan to build and sustain beef demand down the road.

CHAPTER ONE

INTRODUCTION

At the beginning of 2014, the U.S. cattle inventory was at 87.7 million head, the lowest inventory since 1951 (NASS, 2014). Figure 1 shows the historical trend in U.S. cattle inventory since 1950. Severe cases of drought, greater market volatility, and record feed costs led many U.S. cattle producers to downsize their herds in recent years. In fact, the beef cow inventory has fallen 12% since 2007, a drop of approximately 3.8 million head (Hurt, 2014). However, strong beef demand and tight beef supplies in the U.S. have pushed beef and cattle prices to record highs. The decades-low U.S. cattle inventory and more favorable economic conditions in the cattle market have many in the livestock industry discussing the potential for herd growth and the "correct" rebuilding strategy. Genetic, production, and management decisions made in the near term are important for the future success of the beef industry. More importantly, for long term growth, the industry must strive to provide products that will meet consumer desires in order to sustain and improve beef demand.

Figure 1. U.S. Cattle Inventory
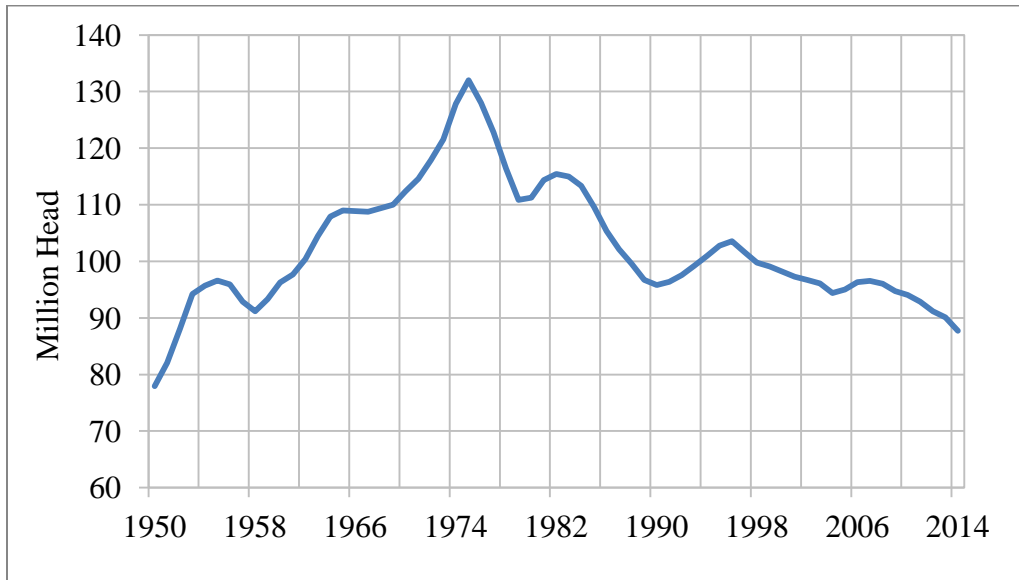
Source: National Agricultural Statistics Service (n.d.)

Regarding consumer beef demand, recent studies suggest a strong consumer focus on quality (e.g. Schroeder, Tonsor, and Mintert, 2013; BQA, 2011). Quality can embody many factors in today's beef industry including nutritional value, healthiness, animal welfare, and environmental concerns. However, Schroeder, Tonsor, and Mintert (2013) addressed beef product quality, in terms of flavor, color, tenderness, and juiciness. Following the lead of these industry experts, "beef quality" will refer to these beef sensory characteristics throughout this study. Beef quality as defined by beef sensory characteristics is indicated by United States Department of Agriculture (USDA) quality grades. Beef of a higher quality grade will have more intramuscular fat which improves flavor, juiciness, and perceived tenderness. Such characteristics contribute to an enjoyable eating experience for the consumer which ultimately drives customer satisfaction and beef demand (Schroeder, Tonsor, and Mintert, 2013).

Product quality is not only an important factor of beef demand, but also a feasibly influenced one (Schroeder, Tonsor, and Mintert, 2013). Now more than ever, cow-calf producers have access to tools that can improve the genetics and production efficiency of their herds in a timely manner. Research by Patterson et al. (2014) at the University of Missouri (MU) Thompson Research Center has proven the industry has the ability to improve beef quality through the use of genetic and reproductive management tools such as estrous synchronization[1], artificial insemination[2] and EPDs[3,4] The MU Thompson Research Center has 30% of cattle grading USDA Prime, 100% grading USDA Choice or higher, and 55% meeting CAB® brand requirements, well above national grading percentages[5] (Patterson et al., 2014). Furthermore, Corah and McCully (2007) pointed out that for many cattle, slight changes in management, nutrition, genetics, health, etc. allow them to achieve better quality grades and bring greater economic returns. With product quality being an important and feasibly influenced determinant of beef demand as addressed by Schroeder, Tonsor, and Mintert (2013), and demonstrated by Patterson et al., differentiating beef demand by quality types (USDA Prime, Choice, Select, and

[1] Estrous Synchronization is a reproductive management tool. Protocols are designed to control estrus and ovulation in cycling females in order to shorten the breeding season (Day and Boyles, n.d.)

[2] Artificial insemination (AI) is the process of collecting bull semen and manually depositing it in the reproductive tracts of heifers or cows (FAO and IAEA, 2014).

[3] Expected Progeny Differences (EPDs) are the predictions of how future progeny of a given animal will perform relative to the progeny of other animals. Each EPD also has an accuracy value that measures the reliability of the prediction. Production, maternal, and carcass EPDs allow producers to make strategic breeding decisions based on where their herd needs improvement (American Angus Association, 2014).

[4] There are numerous benefits using reproductive technologies such as estrous synchronization and AI such as improved pregnancy rates, shortened calving seasons, a more uniform calf crop, access to a greater variety of bulls, and increased genetic selection potential to meet goals for herd improvement. (Seidel, n.d.).
Genetics technologies such as the use of expected progeny differences (EPDs) and genomics testing also add value by creating a faster process for genetic improvement.

[5] National steer and heifer estimated grading percentages for 2013 are 3.7% for Prime, 63% for Choice, and 27.91% for Select (USDA, 2013).

Branded) will help determine whether a quality focused rebuilding strategy has the potential to pay long-run dividends for the beef industry.

The objective of this study is to provide empirical estimates of own-price, cross-price, and income elasticities for beef quality types including USDA Prime, USDA Choice/Branded, and USDA Select beef by means of Ordinary Least Squares (OLS) regression procedures. This approach allows for comparison of these estimated elasticities to help determine the best production focus for the future of the beef industry.

Objectives:

1. Provide empirical estimates of own-price and income elasticities for beef quality types including USDA Prime, USDA Choice/Branded, and USDA Select graded beef, and of cross-price elasticities between beef quality types and competing meats

2. Address the own-price and income elasticity results and the degree of substitution between beef quality types and competing meats

3. Incorporate the estimated single demand equations into the MU Agricultural Markets and Policy (AMAP) group's U.S. beef model to assess impacts of model modifications

4. Discuss whether the empirical results support or oppose a focus on beef quality as part of a herd rebuilding strategy

Results from this study will provide useful information in determining the best rebuilding focus for future success of the beef industry. Some livestock economists argue in favor of a commodity beef strategy to rebuild cattle inventory since ground beef is estimated to be more than 60% of all domestic beef consumption (Rabbobank, 2014). A commodity beef strategy would shift production techniques to focus more on ground beef production

rather than production of high-end beef products. Other experts in the beef industry suggest a rebuilding strategy focused on beef quality. Restaurants such as Five Guys® and Smashburger have created a place for higher-quality beef in the ground beef market. According to Larry Corah, Vice President of Certified Angus Beef®, grinding companies are now offering a variety of ground beef blends, working to create a unique flavor that keeps consumers coming back for more. Even if the beef industry moves toward more ground beef production to target price conscious consumers, beef quality may still play an important role in satisfying consumer beef demand.

The following chapter reviews existing literature regarding meat demand and discusses how further research differentiating beef demand is a valuable contribution to the existing body of knowledge. Chapter three goes through data and single demand equations for each quality grade and discusses estimation results. Chapter four describes the U.S. beef model maintained at the University of Missouri by the AMAP group, talks about how the demand equations from this study are implemented into the model, and analyzes modifications to the model. While the regression results themselves are intriguing, implementing the results into the AMAP U.S. beef model allows more complete analysis of model modifications and provides greater clarity of possible implications for the entire beef industry. Final thoughts and conclusions are found in chapter five. Regardless of where the beef industry is headed, beef quality is a hot topic and the importance of quality as part of a rebuilding strategy should be evaluated.

CHAPTER TWO

LITERATURE REVIEW

History of Beef Demand

A review of prominent events in recent history of the U.S. beef industry as they relate to beef demand may be a helpful first step in the literature review process. From the mid 1970s to the late 1990s, beef demand fell by approximately 50% (Schroeder, Marsh, and Mintert, 2000; Grimes, 2004).

Many experts attributed the loss of market share to a quantity vs. quality approach to beef production and increased production efficiency in both the pork and poultry sectors (e.g. Ferrier and Lamb, 2006; Marsh, 2003; Johnson and Ward, 2006; Schroeder, Mintert, and Brester, 1995; Schroeder, Marsh, and Mintert, 2000). Wohlgenant (1985) accredited the majority of the decline to changes in prices of competing meats resulting from increased production efficiency. Furthermore, increased desire for convenience meals may have also played a role in the decline of beef demand as a larger number of women started working away from home (Eales and Unnevehr, 1987). Regardless of the driving factors behind the downturn, the beef industry was hit hard. Marsh (2003) quantitatively measured the effects of the 20 year decline in beef demand at the farm level. His results showed real slaughter cattle prices and production decreased by 32.1% and 11.2%, respectively, and real feeder cattle prices and production decreased by 8% and 22.6%, respectively. Furthermore, "Slaughter and feeder cattle producers experienced a real revenue reduction of \$13.3 billion (61%) due to the long-term decline in demand"

(Marsh, 2003). After such a period of declining beef demand and revenue reduction, studying and improving beef demand became a priority for the beef industry.

Beginning in the late 1970s, the beef industry started focusing on efforts to improve beef demand and has made significant progress. The Beef Promotion and Research Act passed in 1985, establishing a "producer-funded promotion and research program – the Beef Checkoff – aimed at building demand for beef and beef products," (Cattlemen's Beef Board, 2013). Grid pricing was introduced in 1991 as an attempt to create better incentives for higher quality cattle and clearer price signals from retail to wholesale to farm-level production (Fausti et al., 2010). The first National Beef Quality Audit (NBQA) also debuted in 1991. The NBQA surveyed individuals from all sectors of the beef industry to recognize and gauge beef quality issues in order to establish a beef quality improvement plan that specifically targeted consumer expectations. The NBQA was conducted again in 1995, 2000, 2005, and 2011 (BQA, 2011). However, while all of these efforts contributed to improving consumer demand for beef, the introduction of branded beef programs was arguably one of the most influential efforts to provide consistent high-quality beef products to the marketplace.

 Since their introduction, branded beef programs have become a significant part of the beef industry. Certified Angus Beef® (CAB®) was introduced in 1978 as the first USDA-certified beef program and has remained one of the leading beef brands. Additional branded beef programs developed slowly after the introduction of CAB®, but from 1998 to 2012, 129 new programs hit the market place (Speer, 2013a; 2013b). The rising number of branded beef programs suggests consumers want high-quality beef products backed by brands they can trust (Speer, 2013a). As the number of branded beef programs

rise, it becomes increasingly important to consider the influence of branded beef on aggregate beef demand. Brester and Schroeder (1995) evaluated the impacts of branded and generic meat advertising on demand for beef, pork, and poultry through the use of a nonlinear Rotterdam model. They linked branded beef advertising to increased beef demand and also found substitution among meat commodities due to both brand and generic meat advertising. Branded beef programs not only influence beef demand but also provide consistent products that build consumer trust.

Today, cattle and beef prices have been driven to record highs by strong beef demand and short supply. Following several years of downsizing due to drought, land competition, and market instability, producers will likely begin to rebuild their herds in the near future in the wake of positive market conditions. The likelihood of herd expansion has many industry experts debating the "correct" rebuilding strategy. This thesis contributes useful literature regarding the importance of beef quality as part of a rebuilding strategy by evaluating consumer beef demand for individual quality grades. Every sector of the beef industry must continually strive to provide products that meet consumer expectations in order to sustain and further grow demand for beef in the U.S.

Review of Existing Literature

A review of existing literature reveals numerous studies addressing meat demand, several of them focusing on demand for beef at both retail and wholesale levels. Fewer studies differentiate beef demand for individual products or product categories, and even fewer have attempted to estimate demand for beef disaggregated into specific quality grades. However, such studies provide useful information to direct the path of beef production.

Many meat demand studies have suggested a disaggregated model approach to meat demand estimation. Disaggregation stems from the idea that distinct product categories have their own demand characteristics. Aggregating products into single commodities can hide structural differences in both supply and demand for differentiated products (Brester, 1996). Brester disaggregated beef into ground and table cut categories to compare import demand elasticities. The comparison revealed the importance of disaggregation as the own-price import demand elasticity for ground beef was much less elastic than that of the aggregate beef product while the elasticity for table-cut beef was much more elastic. In 1987, Eales and Unnevehr disaggregated meat demand into meat products in order to better understand separability and structural change. Chicken was disaggregated into whole birds and parts/processed products, and beef was disaggregated into hamburger and table cuts. Eales and Unnevehr's findings revealed how consumers distribute consumption expenditures for meat and provided more detail regarding the sources of structural changes in meat demand in the 1970s and 1980s. Cashin (1991) also disaggregated meat demand into individual product categories similar to the approach of Brester (1996) and Eales and Unnevehr (1987). Beef as an aggregate commodity can also be disaggregated into quality categories as demonstrated by Colman (1966), Zimmerman and Schroeder (2013), and Lusk et al. (2001). "Disaggregation allows a more precise analysis of the demand interrelationships between various types of meat," (Cashin, 1991).

In 1966, Colman estimated the elasticity for two grades of ground beef, low grade and processing beef and high grade beef. This was one of the first attempts to differentiate beef demand according to quality grades. Although the USDA grading system has gone through several changes since Colman conducted his research, his findings are useful. He

showed that beef is not a homogenous commodity and that each quality grade has its own demand characteristics. Demand for low grade and processing beef was price inelastic while demand for high grade beef was price elastic. His findings supported the idea of differentiating beef demand by quality grade. Furthermore, his single equation demand model may still be useful in estimating elasticities across various beef quality types present in today's marketplace.

In 2001, Lusk et al. estimated demand for wholesale quality differentiated boxed beef and looked at the effects of seasonality on beef demand. Firm level factor demands were aggregated into market level demands utilizing monthly boxed beef, wholesale chicken, and wholesale pork data from 1987 to 1999. Their research showed Choice and Select graded beef to be substitutes during the 1st and 4th quarter, but not during the summer months when consumers are set on grilling higher quality beef. While pork was found to be a substitute for Choice and Select graded beef, Chicken was only found to be substitutable with lower quality rather than higher quality beef. Choice and Select beef were relatively own-price inelastic when estimated by Lusk et al. at -0.43 and -0.63, respectively. Demand for Select graded beef was more elastic than demand for Choice graded beef across all four quarters. Additionally, Lusk et al. examined seasonality effects, identifying demand for both Choice and Select graded beef as more inelastic during the summer months. Lusk et al. made significant contributions to differentiating beef demand across beef quality types. However, their focus was on Choice and Select Boxed beef, disregarding beef that graded prime and branded beef. A study such as this thesis which includes Prime and Branded along with Choice and Select beef demand

estimation provides a more complete picture of where consumers stand regarding beef quality and what beef producers must do to meet consumer expectations.

More recent research by Zimmerman and Schroeder (2013) compared CAB® demand with commodity beef demand to allow for better understanding of consumer demand and where CAB® stands within the beef industry. Zimmerman and Schroeder made use of annual boxed beef prices and load count data from the USDA National Comprehensive Boxed Beef Cuts Report and annual CAB® data from 2002 to 2012. Their study presented another case of disaggregated beef demand. It provided estimates for wholesale beef demand separated into CAB® and USDA Choice-and-higher beef by surveying 20 agricultural economists using a Delphi procedure. An Olympic average of the survey results provided the final elasticity estimates for demand from 2002 to 2012 of -0.54 and -0.87 for USDA Choice-and-higher and CAB®, respectively. Estimates of elasticities were combined with sales, price, population, and inflation data to create a wholesale beef demand index to allow for comparison of changes in demand over time. Results showed Choice-and-higher beef demand declined in recent years while CAB® demand continued to improve, suggesting branded beef is an important part of today's marketplace. While Zimmerman and Schroeder's research provided a comparison of demand changes over time for two quality categories, it doesn't allow for comparison of the demands for each quality category in any given year. As noted in the study, the beef demand index will vary with different elasticity estimates. Furthermore, the scope of their research only covers higher-quality beef rather than the full range of beef quality grades.

Reviewing the literature has highlighted several factors as demand influencers such as prices of competing meats, evolving consumer preferences, consumer income, quality

11

grade and seasonality, and the influence of meat brand and advertising effects. However, very few studies have examined beef demand disaggregated across USDA Prime, Branded, Choice, and Select beef quality types. This thesis takes a different approach to evaluate consumer beef demand than previously found in the literature, estimating own-price, cross-price, and income elasticities for USDA Prime, USDA Branded/Choice, and USDA Select quality categories using single equation OLS regression procedures. Conducting a more comprehensive study on beef demand differentiated by quality grades will provide further information on consumer demand as it relates to individual beef quality grades and help beef producers decipher the importance of product quality in terms of a rebuilding strategy.

CHAPTER THREE

DATA, METHODS, AND ESTIMATION RESULTS

Review of Economics

Before jumping into data and estimation results, a basic review of a few economic terms and

principles will be helpful for those who do not have an economic background. Demand for any

good or service is a basic economic principle describing consumers' desire and willingness to pay

for a good or service (Investopedia, 2014). Consumer demand for any good is often a function of

the price of that good, the prices of substitute goods, the prices of goods that are complements,

and income. A demand curve is generally downward sloping with price on the y-axis and quantity

on the x-axis, because as the price of a good increases, individuals typically consume less.

Changes in a good's own-price trigger movements along the demand curve for that particular

good while changes in the prices of substitutes and complements and changes in income cause the

demand curve to shift.

Demand elasticities provide a way to measure how sensitive the quantity movement of a good is

to changes in own-price, cross-prices, and income. Own-price elasticity measures how much the

quantity of a good changes in response to a change in its price. Cross-price elasticities measure

how much the quantity of a good changes in response to a change in the price of a substitute or

complement good. Finally, income elasticities measure how much the quantity of a good changes

in response to a change in consumer income.

Price elasticities are calculated as the % change in quantity divided by the % change in price

(own or cross). Income elasticities are calculated in a similar manner, dividing by the % change in

income rather than price. If the absolute value of the answer is greater than one, the good is said

to be price or income elastic. In other words, the percentage change in quantity is larger than the

percentage change in price or income. If the absolute value of the answer is less than one, the good is said to be price or income inelastic. The percentage change in quantity is smaller than the percentage change in price.

Alternatively, or inversely, the sensitivity of price to a change in quantity is measured by price flexibility. A price flexibility is the inverse of an elasticity, calculated as the percentage change in price divided by the percentage change in quantity. In terms of beef demand, price flexibilities can provide a measure how much price premiums for higher-quality beef will decrease in response to an increase in production.

A basic understanding of economic concepts such as demand, elasticities, and price flexibilities is useful in comprehending the results of this thesis.

Data

The ultimate focus of this research is to examine consumer beef demand differentiated by quality categories. While retail beef data would prove most useful in estimating consumer beef demand, analyzing wholesale markets includes the effects of beef demand developments in food service and international markets. Also, given that retail beef data differentiated by quality type were not available, wholesale level beef quantity and price data were used to estimate consumer beef demand from 2005 to 2013.

Monthly quantity and price data for USDA Prime, Branded, Choice, and Select loads of boxed beef were gathered from the Agriculture Marketing Service (AMS) through the Livestock Marketing Information Center (LMIC). Since USDA Branded boxed beef is made up of branded upper 2/3 and lower 1/3 Choice beef, Branded and Choice quantity data were combined into one quality category, with price determined by a weighted

average. Prime, Branded/Choice, and Select price and quantity information are shown in

Figures 2, 3, and 4.

Figure 2. Boxed Beef Cutout Values
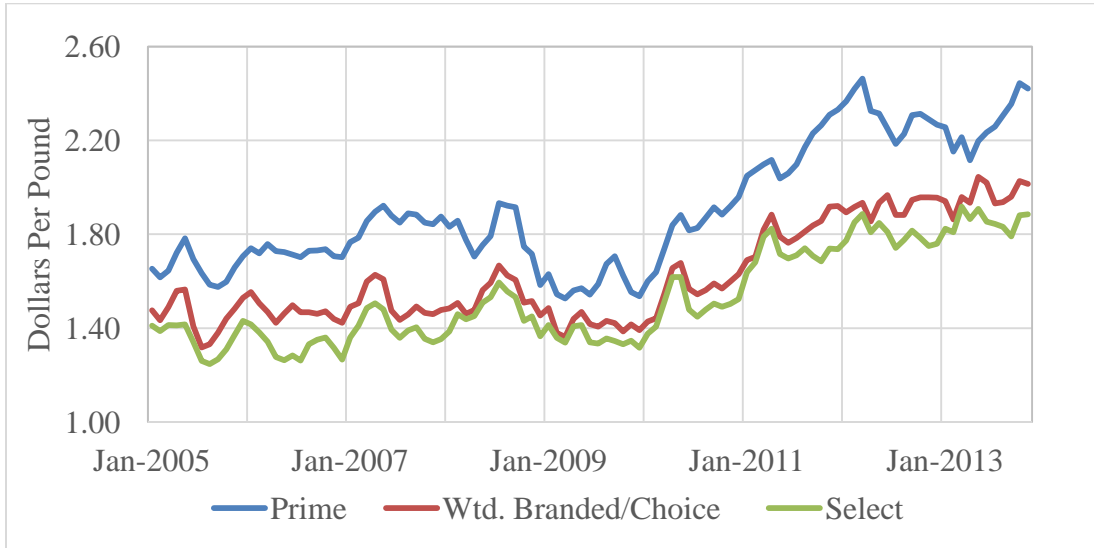
Source: United States Department of Agriculture, Agricultural Marketing Service; Livestock Marketing Information Center

Figure 3. Select and Branded/Choice Quantity Sold
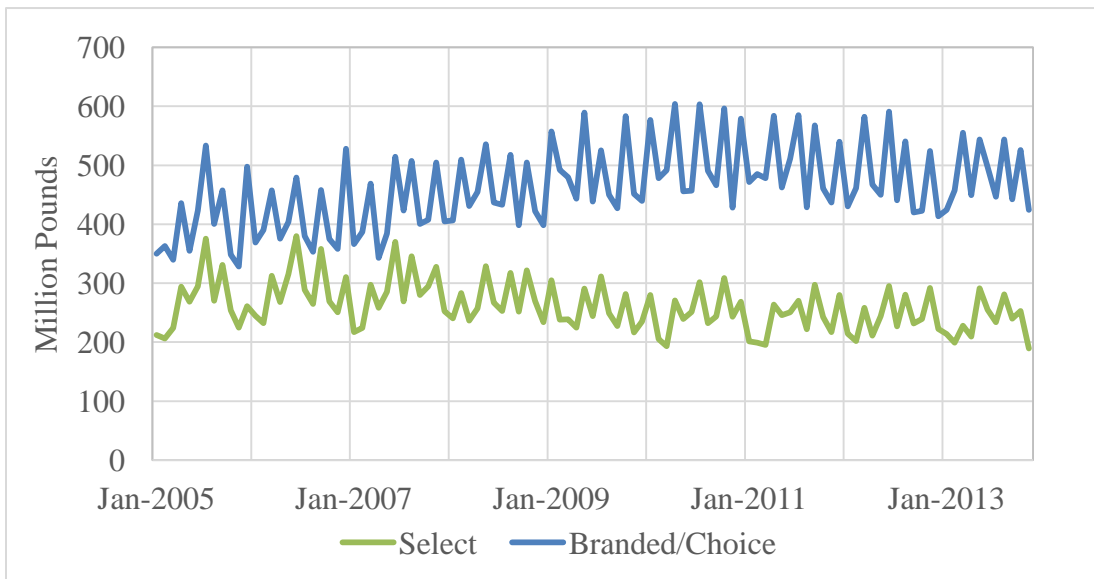
Source: United States Department of Agriculture, Agricultural Marketing Service; Livestock Marketing Information Center

Figure 4. Prime Quantity Sold
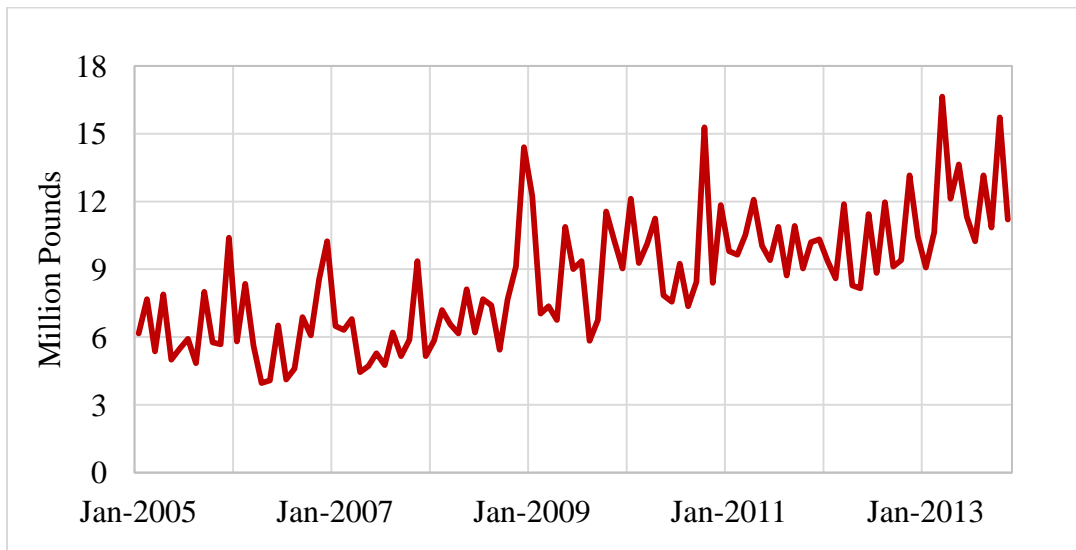
Source: United States Department of Agriculture, Agricultural Marketing Service; Livestock Marketing Information Center

As personal income influences beef demand, income is included in each model represented by monthly Real Personal Consumption Expenditure data obtained from the United States Department of Commerce, Bureau of Economic Analysis.

Monthly pork cutout values and wholesale chicken prices were gathered from the Economic Research Service (ERS) to estimate cross-price elasticities for these competing meats.

Quantity and income data were adjusted according to Mid-Month Population data from the United States Department of Commerce, Bureau of Economic Analysis. Price data were adjusted for inflation using the Consumer Price Index.

Methods and Estimation Results

OLS regression procedures were used to estimate three single demand equations with natural log (ln-ln) specifications. This approach allowed for the empirical estimation of income and own-price elasticities for USDA beef quality grade categories including Prime, Branded/Choice, and Select and the estimation of cross-price elasticities between quality grade categories and competing meats. Cross-price elasticities allow us to determine the degree of substitution among beef quality types and between beef-quality types and competing meats.

Quarterly dummy variables were included in each model to account for seasonality in beef demand. Pork and chicken prices were combined, using a simple average, into one competing meats price variable to reduce the number of estimated parameters.

Elasticities for Prime, Branded/Choice, and Select graded beef are shown in Table 1.The ln-ln specifications of each equation allow coefficients to be directly interpreted as elasticities. When examining the elasticity results, it is important to remember that the time period and the nature of the data used for estimation matter. Monthly data likely results in larger elasticities than annual data. Similarly, disaggregated demand will likely be more elastic than aggregate demand as the aggregate response is the sum of the disaggregated elasticities.

The estimated elasticities show that a 1% increase in the Prime price (cutout value) decreases the quantity of Prime beef consumed by 2.33%. If the price of competing meats were to increase by 1%, the quantity of Prime, Branded/Choice, and Select beef consumed would increase by 0.21%, 0.24%, and 0.30%, respectively. A 1% increase in

income would increase the quantity of Prime, Branded/Choice, and Select beef consumed

by 1.34%, 0.03%, and 1.26%, respectively. First, second, and third quarter estimates

address changes in quantity of beef consumed due to seasonality. Finally, a logarithmic

trend was included in each model to account for additional non-economic factors or

consumer behavioral variables that may influence beef demand. Beef tenderness is an

example of a possible non-economic variable that might be at play. We don't have a

reliable method of measuring consumers' behavior relative to beef tenderness, but it may

influence demand for different quality grades of beef. The trend term is found to be

significant across all beef quality types, indicating increasing demand for higher quality

beef and decreasing demand for lower quality beef not accounted for by demand factors

already explicitly included in each model.

Table 1. Beef Demand Elasticities by Quality Grade

	Prime Quantity	Branded/Choice Quantity	Select Quantity
Constant	-2.65	-3.17	0.83
Prime Price	-2.33**	0.25	0.30
Branded/Choice Price[a]	1.53	-1.04	0.13
Select Price	1.18	0.22	-1.24*
Competing Meats Price[b]	0.21	0.24	0.30
Income	1.34	0.03	1.26
1st Quarter	-0.14*	0.00	-0.08
2nd Quarter	-0.29**	0.04	0.07
3rd Quarter	-0.21**	-0.06	0.03
Trend	0.16**	0.07**	-0.05**
R-squared	0.70	0.65	0.74
[a] Branded/Choice Price is the weighted average of Branded and Choice beef cutout values			
[b] Competing Meats price is the simple average of pork and chicken prices.			
* and ** indicate significance at the 5% and 1% level, respectively.			

According to the results, Prime beef is the most elastic beef product. USDA Prime beef is more own-price elastic than the other beef quality types. As the own-price increases by 1% for each quality type, the percentage change of beef consumed changes the most for Prime beef at -2.33%. Many in the cattle industry suggest that the premiums available for high-quality beef are driven in large part by limited supplies. While supplies do play a role in determining market clearing prices, relative demand elasticities also play an important role in determining premiums available for high-quality beef, as demonstrated with the Prime own-price elasticity. A more elastic own-price suggests that a change in quantity supplied elicits a smaller change in price. Additionally, the price flexibility for Prime beef demand is -0.43 suggesting the percentage change in price is smaller than the percentage change in quantity. Thus the market can, to some extent, absorb an increase in the quantity of Prime beef supplied without severely reducing quality premiums.

Income elasticities are largest for Prime and Select Beef. The results show demand for Prime beef is the most responsive to changes in income, followed by demand for Select, and Branded/Choice beef. The low income elasticity for the Branded/Choice category is somewhat unexpected but may be influenced by shifts among income levels. From these results, we can infer that as incomes allow, consumers will demand more beef, especially of higher quality such as beef that grades USDA Prime.

A logarithmic trend applied from 2007 to 2013 is significant across each beef quality category. This trend suggests additional factors are increasing demand for Prime and Branded/Choice beef and decreasing demand for Select beef which will lead to stronger demand for higher-quality beef products in the future. While it's difficult to

quantitatively identify exactly what is underlying this trend, Table 2 shows significant

changes in demand of each quality category if the non-economic variables were to

continue influencing beef demand for different quality grades through 2025. While Prime

and Branded/Choice beef consumption would increase, Select beef consumption would

drastically decrease under the assumption of a continued trend.

Table 2. Annual Change in Demand if Trend Continues Through 2025

	(million pounds)		
	Prime	Branded/Choice	Select
2015	2.65	47.53	-17.97
2016	2.40	42.63	-15.89
2017	2.20	38.67	-14.24
2018	2.03	35.41	-12.89
2019	1.89	32.67	-11.77
2020	1.77	30.33	-10.83
2021	1.67	28.44	-9.97
2022	1.58	26.80	-9.23
2023	1.50	25.25	-8.62
2024	1.42	23.89	-8.08
2025	1.36	22.67	-7.61
Total	20.47	354.29	-200.73

Lower quality beef faces the strongest pressure from competing meats. The regression

results show positive elasticities for all cross-prices across all beef quality categories.

These results imply substitution among beef quality grades and between each beef quality

grade and competing meats. However, the degree of substitution differs across beef

quality categories. According to the results, a change in the price of competing meats

elicits the strongest response in quantity of Select beef demanded followed by quantities

of Branded/Choice, and Prime beef demanded. In other words, Select beef faces stronger

competition with pork and chicken than beef that grades prime. In fact, the competing

meats cross price elasticity for Prime beef is only 2/3rds that of Select beef. This becomes important as the livestock industry is finally realizing lower feed costs after several years of high feed prices. The expected response for both the pork and poultry industry is to increase production. Increased production of these competing meats will drive pork and chicken prices down and create more price pressure on beef. The estimation results show Select has the highest degree of substitution with competing meats, suggesting lower-quality beef will face the most price-pressure from other meats.

The results from these three single demand equations imply rising consumer demand for higher-quality beef and falling demand for lower-quality beef. While the single equations can stand alone, the following chapter links these single equations to a more comprehensive U.S. beef model to forecast future implications for the beef industry given our estimation results.

Value of Quality

Results from these three single demand equations imply rising consumer demand for beef of higher-quality such as USDA Prime and USDA Branded/Choice beef and falling consumer demand for USDA Select beef. Demand figures can be found in the Appendix. Increasing demand for higher-quality beef is a sign of increased potential to add value to the beef industry through quality premiums. In an effort to quantify the added value from quality premiums, a premium cutout value was compared to a baseline cutout value, similar to the methods used in the CattleFax report "The Value of Quality." The baseline cutout was a composite of USDA Choice and USDA Select cutout values based on grading percentages. The premium cutout followed the same composite method with the

addition of Prime and Branded beef values. The comparison of the baseline and premium cutout values gives an idea of the value of higher-quality beef.

From 2005 to 2013, quality premiums made up approximately 1.3% of the value of U.S. cattle and calf production, adding nearly 4.5 billion dollars to the beef industry. In 2013 alone, quality premiums added 630 million dollars to the beef industry. Furthermore, Figure 5 shows the value added from quality premiums has largely been trending upward since 2005. Increasing demand for higher-quality beef, as suggested in this study, provides an incentive for increased production of high-quality beef. With quality categories such as Prime being more own-price elastic, the market can, to some extent, absorb an increased supply of beef products in these categories without driving quality premiums down. Consumers have shown willingness to pay premiums for higher quality beef, and producing a greater supply of higher-quality product will increase the value added by beef quality, an already significant contribution to the beef industry.

Figure 5. Value Added to U.S. Beef Production through Quality Premiums
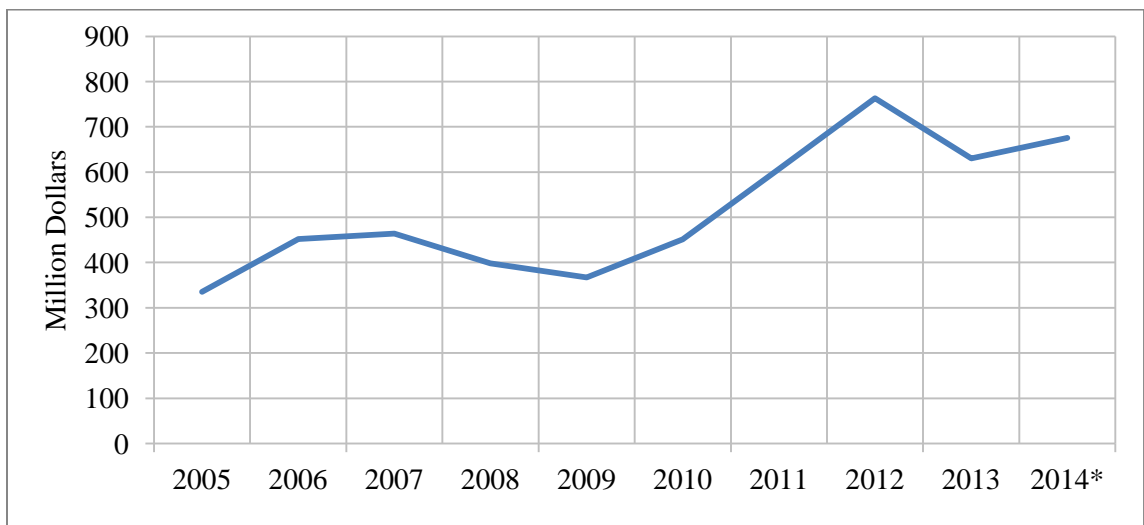
* 2014 value estimated from eight months of data

CHAPTER FOUR

THE U.S. BEEF MODEL

Model Description

The U.S. beef model maintained at the University of Missouri by the Agricultural Markets and Policy group (AMAP) is a structural econometric approach to capturing the important decision points in the beef industry. For many years, the beef modeling structure was maintained in the Food and Agricultural Policy Research Institute at the University of Missouri. The model is made up of estimated equations, technical relationships, and closing identities that attempt to replicate the major decisions that occur in the U.S. beef industry. The current version of the beef model is estimated by single equation methods and covers the period from 1988 to 2011.

Though parameters have been updated over time, this model has been used for many years to measure the effects of movement of factors that are important to the U.S. beef industry. The primary role of this structural model has been to measure the impacts of various federal agricultural and livestock policies. This modeling approach is comparable to the USDA Food and Agricultural Policy Simulator (FAPSIM) model. FAPSIM is an annual econometric model of the U.S. agricultural sector developed by the USDA's Economic Research Service and is also used to simulate the effects of different policies (Westcott and Price, 2001). While these two models are similar, they are not identical.

The AMAP group's model includes behavioral equations that determine the supply of beef. Behavioral equations are estimated for beef cow inventory, beef cow slaughter and cattle placed on feed. The beef cow supply side equation is driven by expected net returns

which include steer, heifer, and cull cow receipts and feed and other variable production costs. Steer and heifer receipts are based on feeder steer prices which also drive the number of cattle placed on feed in a given year. Cull cow receipts are driven by the boning utility cow price.

On the demand side, beef demand is linked to the larger livestock model including pork, chicken, and turkey to allow changes in the beef sector to affect other meat sectors. A wholesale meat demand equation is specified as a function of per capita income and a weighted wholesale meat price including beef, pork, chicken, and turkey. Individual demand equations are calculated as shares of wholesale meat demand. The wholesale meat demand equation is first split into red meat and poultry shares which are each then broken down into individual meat commodity shares. Beef demand as a share of the red meat wholesale demand is a function of boxed beef price and pork cutout price.

The beef model also includes technical equations such as calf crop which depends on the number of cows in both the beef and dairy herds and the feedlot cost of gain which is driven by the price of corn and soybean meal. Additionally, the model includes equations that link beef retail price to wholesale beef price, wholesale beef price to fed steer price, and fed steer price to feeder steer price. Each of these equations represents an important technical relationship within the beef industry.

Additionally, the AMAP beef model accounts for exports and imports. Beef exports are estimated as a function of real boxed beef price, real pork and chicken prices, and real world GDP and beef imports are estimated as a function of cull cow price and beef cow

slaughter as beef imported by the U.S. is primarily a leaner product used for ground beef and processing.

While the AMAP model in its current state is able to forecast demand for beef as an aggregate commodity, it is not equipped to disaggregate beef demand into individual quality categories. The next section of this chapter provides detail on how the single demand equations for individual quality grades estimated in this thesis were incorporated into the AMAP beef model to disaggregate forecasted beef demand.

Implementing Single Demand Equations

The single demand equations estimated by this thesis for individual beef quality grades were incorporated into the AMAP beef model to provide greater clarity of possible implications for the entire beef industry from changes in consumer demand for different quality levels of beef. In order to implement the quality grade demand equations into the beef model, the nature of the demand equations had to be altered from a system approach that derived beef consumption from an estimated share of total wholesale meat demand to a system that estimated beef consumption directly. Aggregate beef demand was split into four single demand equations, one for each USDA quality category. As covered in chapter three, Prime, Branded/Choice, and Select beef demand equations were estimated according to OLS regression procedures with natural log (ln-ln) specifications. The estimation did not include an equation for Ungraded beef as it is made up of cuts, trims, and grinds and is not quality graded by USDA. Therefore, a general equation for Ungraded beef demand was specified as a function of own price, competing meat prices, and consumer income. Under the assumption that Ungraded beef demand would have the

same underlying relationships with own and competing meat prices and income as aggregate beef demand, Ungraded beef demand elasticities were calibrated to the same level as those determined from the AMAP aggregate beef model. Demand equations for pork and chicken were also specified in single-equation form, retaining the same underlying elasticities as those derived from the system approach used in the AMAP aggregate model.

Because the quality grade demand equations were estimated independently of the beef model using different data, assumptions and adaptations were made to reproduce the beef supply and demand equilibrium contained in the aggregate model. The single demand equations for quantity demanded for each beef quality grade were estimated using AMS boxed beef data while the aggregate beef demand equation was estimated using beef civilian disappearance data from ERS. Total pounds of beef production according to boxed beef loads data does not directly match total pounds of beef civilian disappearance within any given period. Therefore, the boxed beef quantity data used to estimate the quality grade demand equations was adapted to fit the beef civilian disappearance data to maintain consistency with the production and trade data contained in the AMAP aggregate beef model. This was done by calculating the percentages of Prime, Branded/Choice, and Select boxed beef loads of the total annual loads volume reported by AMS and applying those percentages to total beef civilian disappearance to calculate beef civilian disappearance of individual quality grades. The percentage of Ungraded boxed beef was allotted so that the total percentage equaled 100 and was applied to total beef civilian disappearance in the same manner as the other quality grade categories. Adapting the data in this way allowed the single demand equations for individual quality

grades to be incorporated into the larger beef model without disrupting the total U.S. beef supply and demand equilibrium.

Just as the boxed beef quantity data had to be adapted to fit into the beef model, the boxed beef price data for individual quality grades was also adapted to correspond to the comprehensive wholesale beef price currently included in the aggregate beef model. While the cutout values for each beef quality category contribute to the comprehensive boxed beef cutout value, no direct calculation could be found to exactly replicate the comprehensive value from the quality category values[6]. Consequently, the comprehensive boxed beef cutout value was estimated as a function of the weighted average cutout value of the individual quality grade prices. The estimated equation came very close to replicating the comprehensive value over the historical period.

Price equilibrators were added to the beef model to determine the price equilibrium for each beef quality category. Price equilibrators are based on the principle that demand must equal supply (Meyer et al, 2006) and because of this principle, are able to solve for price equilibrium. For each quality grade category, a price equilibrator was set up by calculating the difference between demand, estimated by the respective single demand equation, and supply, calculated by applying the boxed beef loads percentage of the respective quality grade to aggregate beef supply. When an imbalance exists between supply and demand, the spreadsheet model adjusts the equilibrium price until quantity supplied is equal to quantity demanded. For instance, an increase in income will result in

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[6] AMS reports the comprehensive boxed beef cutout value to be a weighted average of the cutout values for individual quality grades (AMS). However, computing the weighted average of the cutout values with available data did not yield the correct comprehensive boxed beef cutout value.

an increase in beef quantity demanded, which creates a supply-demand imbalance. The price equilibrator will respond by adjusting the price upward to stimulate increased supply while at the same time reducing the quantity demanded. This process will continue until the price has reached the equilibrium level where supply equals demand.

The ability of the beef model to adjust to changes in supply and demand factors makes it useful for forecasting outcomes of various scenarios and policies. Furthermore, linking the single demand equations for individual quality grades to the AMAP aggregate beef model allows outcomes to be forecasted at a disaggregated level and provides greater clarity of possible implications for the entire beef industry from changes in consumer demand for different quality levels of beef. The final two sections of this chapter cover baseline estimates used to assess impacts of shocks to the beef model and discuss the resulting implications of extending the logarithmic trend found to be significant for each quality grade category throughout the forecast period.

Baseline

Baseline estimates of modeled variables were obtained from the original AMAP beef model in order to assess the impacts of relevant shocks and scenarios. The AMAP beef model is used to estimate the University of Missouri Food and Agricultural Policy Research Institute's (FAPRI) baseline beef sector projections. The projections were recently updated in August of 2014 (FAPRI and AMAP, 2014). Forecasted baseline results are available through 2025. Discussion of the baseline will focus on inventory, prices, and production of the U.S. beef sector with a few highlights of competing meat sectors.

Beef herd expansion over the next few years is expected given the current state of the beef industry with historically low cattle inventory and record beef prices. The baseline estimates from the AMAP beef model align with this expectation. Beef cow inventory is projected to begin a turnaround in 2015 and continue increasing through 2019, growing by 1.3 million head. Following the characteristics of a typical cattle cycle (Matthews et al, 1999), after five years of projected expansion, the beef cow inventory is shown to begin another period of declining inventories from 2020 through the end of the forecast period. With the projected growth in beef cow inventory, steer and heifer slaughter is expected to temporarily decrease as beef producers will likely retain more animals for breeding stock and herd expansion. The domestic cattle supply and steer and heifer slaughter will begin to increase once the retained animals begin producing offspring. With supply remaining low for the first two years of the forecast period, prices will remain high through 2015 before they gradually start to decline as cattle supply grows. Cattle and beef prices are projected to bottom out in 2020 as the beef cow inventory peaks but remain well above 2013 levels for the entirety of the forecast period. High beef and cattle prices at the start of the forecast period combined with lower feed costs result in record net returns for beef producers projected to be over 300 dollars per cow. However, net returns per cow will eventually come down from record levels as prices decrease projected to fall below 50 dollars per head by 2020 and remain at this level through the end of the forecast period. Per capita consumption of beef has been falling since 2006 and due to record prices in grocery stores across the U.S., is expected to be down again in 2014 and 2015. While per capita beef consumption is expected to increase as prices fall over the forecast period, it still remains below the 2006 level.

Production Scenario

In order to test the reliability of the model, a production scenario was tested in both the original AMAP beef model and the model with the addition of the single quality grade demand equations and the responses of each model were compared. Production was exogenously increased by 500 million pounds each year of the forecast period in both models. Resulting changes from the baseline are compared in Table 3.

Table 3. Differences in Production Scenario Forecast Results

|	2014	2017	2020	2025
	Million Head			
Beef cows (Jan. 1)	0.00	-0.03	-0.02	0.00
Cattle and calves (Jan. 1)	0.00	-0.04	-0.05	-0.02
Cattle on feed (Jan. 1)	0.00	0.00	-0.01	0.00
Beef supply and use	Millions of Pounds			
Production	-0.37	-7.47	-13.14	-4.92
Domestic Use	-0.75	-7.27	-13.06	-5.02
Ending Stocks	0.32	-0.14	-0.48	-0.13
Per Capita Consumption	Pounds			
Carcass Weight	0.00	0.0	-0.04	-0.01
Retail Weight	0.00	-0.02	-0.03	-0.01
Prices	Dollars Per Hundredweight			
Total All Grades, 5-Area Direct Steers	-0.29	-0.07	0.09	-0.02
600 - 650 #, OKC Feeder Steers	-0.56	-0.13	0.17	-0.03
Boxed Beef Cutout	-0.43	-0.11	0.10	0.16
	Dollars Per Pound			
Beef Retail	0.00	0.00	0.00	0.00
	Dollars Per Cow			
Cow-Calf Net Returns	-2.79	-0.69	0.76	-0.22

Increasing production for each year of the forecast period elicits a very similar response in both models, confirming reliability. Figure 6 and 7 compare forecast results for beef cow inventory and boxed beef cutout values.

Figure 6. Comparison of Beef Cow Inventory Forecasts
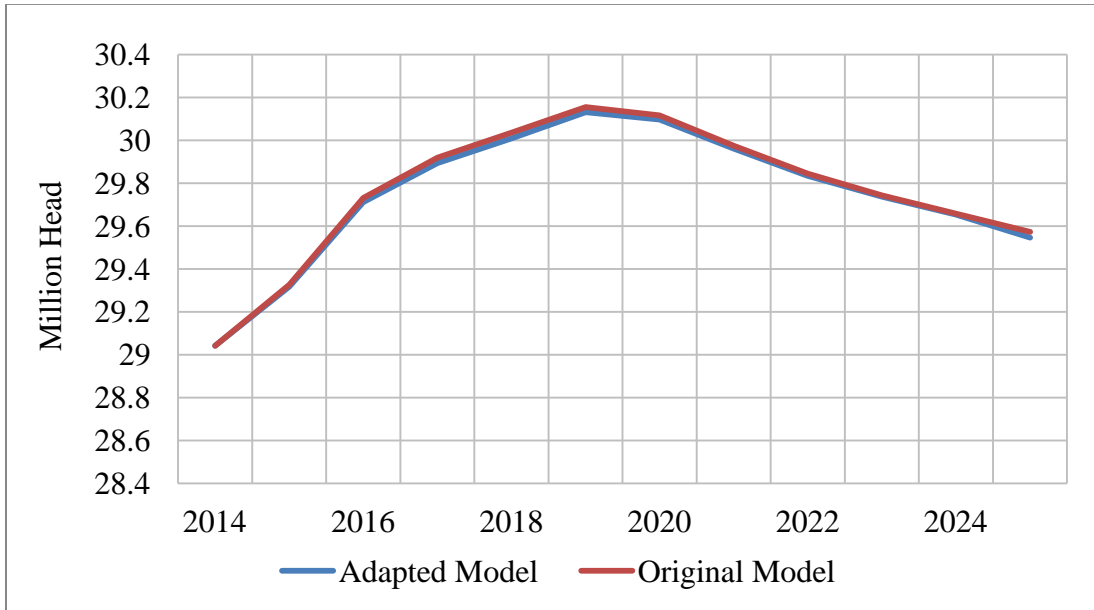
Figure 7. Comparison of Boxed Beef Cutout Value Forecasts
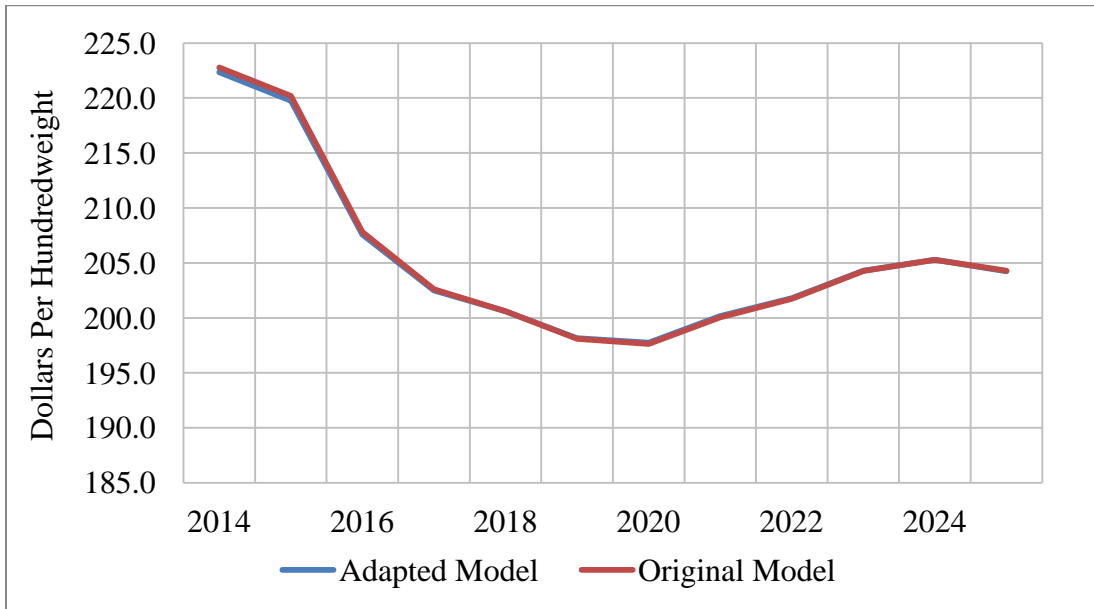
While the results for aggregate beef demand and supply are similar between the two models, the model with the quality grade single demand equations provides insight into what is happening in the markets for individual beef quality grades, insight that isn't available from the original model. Information regarding individual quality grade market expectations allows those in the beef industry to make more informed production decisions. Although the aggregate results don't explicitly show it, the single demand equations for individual quality grades are a valuable contribution to the AMAP beef model, providing more information to inform industry decisions.

Trend Scenario

In order to test the responsiveness of the model to changes in consumer beef demand for individual beef quality grades, a shock was imposed to extend the logarithmic trend found to be significant for consumption of each quality grade to the end of the forecast period. As described in chapter 3, a positive logarithmic trend was significant in the demand equations for Prime and Branded/Choice beef and a negative logarithmic trend was significant in the Select beef demand equation. The significant trend suggests an increase in the consumption of Prime and Branded/Choice beef and a decrease in Select beef consumption not accounted for by demand factors already explicitly included in each model. Results of extending the trend through the forecast period will be assessed by comparing the scenario forecast to the baseline.

While it is difficult to quantitatively identify exactly what is underlying the trend, Table 2 showed significant changes in beef demand for each quality grade with a net increase in beef demand simply by extending the trend through 2025. As the trend suggests

increasing demand for higher-quality beef and falling demand for lower-quality beef, assessing the implications of extending the trend through the forecast period will provide valuable insight as to how a focus on higher-quality beef may change the outlook of the beef industry. Applying this shock to the aggregate model allows for a more complete assessment of the implications than shown in Table 2. Industry implications are shown in Table 4 with absolute changes listed below the baseline estimates for each factor.

Table 4. Implications of Extending the Trend

	2014	2017	2020	2025
		Million Head		
Beef cows (Jan. 1)	29	30.49	30.82	30.15
Change	0	0.26	0.49	0.7
Cattle and calves (Jan. 1)	87.73	90.41	91.66	89.85
Change	0	0.35	0.93	1.58
Cattle on feed (Jan. 1)	12.7	13.53	14.03	13.89
Change	0	0.04	0.13	0.25
Beef supply and use		Million Pounds		
Production	24505.3	25358.55	26764.9	26656.09
Change	2.31	70.85	212.27	392.52
Domestic Use	24549.1	25117	26211.66	26179.89
Change	4.52	69.91	210.73	391.71
Ending Stocks	509.94	551.91	599.78	609
Change	2.2	1.25	-3.22	-8.68
Per Capita Consumption		Pounds		
Carcass Weight	76.96	76.94	78.48	75.54
Change	0.01	0.21	0.63	1.13
Retail Weight	53.87	53.86	54.94	52.88
Change	0.01	0.15	0.44	0.79
Prices		Dollars Per Hundredweight		
Total All Grades, 5-Area Direct Steers	150.42	131.14	123.49	127.73
Change	2.01	2.93	2.77	2.91
600 - 650 #, OKC Feeder Steers	212.75	177.09	161.22	172.71
Change	3.84	5.55	5.26	5.55
Boxed Beef Cutout	230.79	207.36	199.38	205.89
Change	2.93	4.42	4.52	5.26
		Dollars Per Pound		
Beef Retail	5.85	5.68	5.57	6.17
Change	0.03	0.06	0.06	0.07
		Dollars Per Cow		
Cow-Calf Net Returns	327.03	141.89	35.45	34.43
Change	19.02	28.31	28	31.65
Competing Meat Prices		Dollars Per Pound		
Pork cutout value	109.43	84.77	94.68	91.29
Change	0.38	0.28	0.25	0.31
National Composite Wholesale Broiler	101.72	92.45	97.89	101.29
Change	0.17	0.12	0.12	0.15

*Beef imports and exports remain exogenous in this scenario. Therefore, imports and exports do not change from baseline levels and are not included in the table.

Given the net impact of the trend on beef demand, one would expect per capita consumption of beef to be above baseline levels with the trend extended through the forecast period. The model projects annual per capita retail weight beef consumption to gradually increase over the forecast period, ending 0.79 pounds above the baseline level by 2025. As demand increases, prices will also rise. Beef prices across the board are above baseline levels throughout the forecast period. The trend is expected to add $2.93 per hundredweight to the boxed beef cutout value in 2014 and $5.26 per hundredweight to the cutout value in 2025. Alternatively, the retail beef price is expected to be $0.03 per pound above the baseline in 2014 and $0.07 per pound above in 2025.

Higher prices and increased beef consumption translate into greater net returns for cow-calf producers. Model projections show the trend increases cow-calf net returns above baseline levels for the entirety of the forecast period adding approximately $19.02 per cow to producers' pockets in 2014 and approximately $31.65 per cow by 2025. With cow-calf net returns expected to be above $300 in 2014 and still above $100 in 2017, the increased net returns above baseline levels may not have much additional impact on beef production decisions in the short term. However, net returns per cow are expected to fall below $50 by 2020. Therefore, in the long term, the additional net returns resulting from the trend nearly double total net returns per cow, suggesting the trend may have a greater impact on production decisions as time goes on. However, additional costs of reproductive technologies and management tools are not included in the forecast. Individuals may question how the additional costs associated with an increased focus on beef quality might influence the forecast projections, but the trade-offs are not clear. Implementation of new technologies and reproductive management tools can potentially

cover additional costs and labor through efficiency gains such as shorter calving seasons, higher calving rates, and more uniform calf crops. Comparing incurred costs and cost savings of an additional focus on beef quality is difficult, but the forecasted cow-calf net returns imply an increased focus on producing high-quality beef will pay off in the short term and even more so in the long term. Furthermore, projected cow-calf net returns above baseline levels at the end of the forecast period suggest an increased focus on beef quality may reduce risk going into the next downturn of the cattle cycle, buffering producers from cycle lows.

If demand for higher-quality beef continues to rise as suggested by the trend, the model projects an additional 2.31 million pounds of beef production in 2014 and nearly 400 million pounds of additional beef production in 2025. The trend shows increased consumption of Prime and Choice and decreasing consumption of Select beef. Therefore, one would expect the additional production above baseline levels to be aligned with projected beef demand and be primarily production of higher-quality beef.

As for competing meats such as pork and chicken, wholesale prices are expected to be above baseline levels throughout the forecast period. Facing higher beef prices under the assumption of a continued trend compared to baseline levels, consumers and retailers will likely increase their level of substitution of other meats. Increased substitution of pork and chicken will increase demand for both meats and drive pork and chicken prices higher which results in price estimates above baseline levels for both meat categories throughout the forecast period. However, the resulting increases above baseline price estimates are larger for pork than for chicken. This may be a sign that pork is the stronger substitute which follows the findings of Lusk et al regarding the substitutability of pork

and chicken with higher-quality beef. If pork truly is the stronger substitute of the two competing meats, pork demand will increase more than chicken demand in the wake of higher beef prices resulting in a larger increase in pork prices as projected by the model. While the degree of substitution may differ for pork and chicken, forecast results imply that both meats are indeed substitutes for beef.

Identifying the underlying factors of a trend is often difficult but doesn't mean the trend itself should be ignored. With the beef industry being in a state of short supply and strong demand, a new cycle of expansion is about to begin. Finding a trend that shows increasing demand for higher-quality beef and decreasing demand for lower-quality beef resulting from factors other than those explicitly included in the quality grade models contributes to the discussion of a rebuilding strategy focused on producing higher-quality beef. Running the model with the trend continued through 2025 provided a snapshot of how the beef industry might be different if demand continues to increase for higher-quality beef in the U.S. The results were directionally consistent with basic economic principles. If the trend continues, the model projects not only direct impacts on the beef sector but also indirect impacts on the pork and chicken sectors, as well.

CHAPTER FIVE

SUMMARY AND CONCLUSION

## Summary

The decades-low U.S. cattle inventory has many in the livestock industry discussing the potential for herd expansion. With improved economic conditions and strong beef demand in today's market, beef producers will likely begin to grow their operations and rebuild their herds in the near future. The intent of this work was to help better define the focus for rebuilding cattle herds in the U.S. by estimating U.S. consumer beef demand for individual USDA quality grades. While there are a few existing studies that looked at beef demand for various quality grades, they did not cover the full spectrum of USDA quality grades used in the current beef grading system. The results of this thesis contribute to the gap in the literature regarding beef demand for individual quality grades. Furthermore, implementing single demand equations for individual beef quality categories into a larger aggregate beef model provides greater clarity of possible implications for the entire beef industry from changes in consumer demand for different quality levels of beef.

Results of this thesis imply rising consumer demand for beef of higher-quality such as USDA Prime and Choice beef, which included USDA branded beef in this study, and falling consumer demand for lower-quality beef. These results are important in terms of building future beef demand from recently low U.S. consumer demand index values, shown in Figure 8.

Figure 8. U.S. Consumer Beef Demand Index
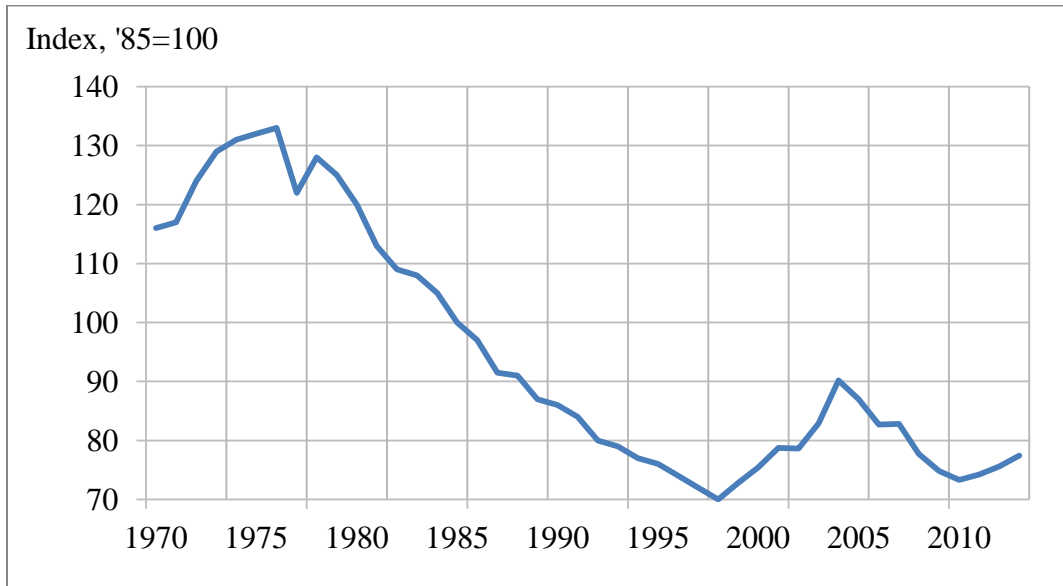
Source: Agricultural Electronic Bulletin Board (n.d.);Grimes (2004)

Furthermore, the logarithmic trend found to be a significant in all three beef quality demand equations suggest factors other than those already explicitly included in the quality grade models are driving demand for higher-quality beef. The scenario forecast shows positive implications for the beef industry such as increased cow-calf net returns, increased production, and increased per capita consumption if the trend for each beef quality grade continues.

Contrary to what beef producers might think, the large own-price elasticity for Prime beef suggests the market can, to some extent, absorb an increase in higher-quality beef production without severely reducing quality premiums. While quality premiums may decrease, the percentage decrease is expected to be smaller than the percentage increase in quantity. Prime beef having the largest own-price elasticity follows the results of Colman (1966) that found high grade beef to be more elastic than low grade processing

beef. Additionally, Lusk et al. (2001) found Select graded beef to be more elastic than Choice graded beef which also aligns with the results of this study.

While the empirically estimated demand elasticities show substitution among beef quality grades and between each beef quality grade and competing meats, the degree of substitution differs. Demand cross-price elasticities show that lower-quality beef is likely to face the strongest competition from competing meats such as pork and chicken. Results of continuing the positive demand trend for higher-quality beef suggest pork may be a stronger substitute than chicken as beef prices rise.

Throughout the forecast period, scenario results show an industry drive to meet rising demand for higher quality beef will increase net returns to cow-calf producers, increase production, and increase per capita consumption of beef. These findings suggest a focus on beef quality to be a logical rebuilding strategy.

Future Research

While retail beef data would prove most useful in estimating consumer beef demand, retail level data disaggregated according to quality grade is not currently available. Such data, if it were to become available would prove useful for future research involving consumer demand estimation for individual beef quality grades.

The results of this thesis provide evidence that consumers substitute pork and chicken for beef, but because these two meats were combined into one competing meats category for the demand estimation, the exact degree of substitution between each competing meat and each quality grades is unclear. A different research approach is necessary to evaluate the exact levels of substitution between beef quality grades and competing meats.

Income data was not separated into earnings categories for this study, but the income elasticity estimates suggest income levels and shifts between income levels may influence demand for different quality grades of beef. Investigating the relationships between different income levels and demand for different beef quality grades is another topic for future research.

Additionally, future research is needed to identify the factors, economic or not, underlying the logarithmic trend found to be significant across all beef quality categories in this study. Recognizing the additional factors that are increasing demand for higher-quality beef while at the same time decreasing demand for lower-quality beef will contribute to a fuller understand of U.S. consumer demand for beef.

Finally, more research is needed regarding the costs associated with new genetic and reproductive management technologies. Change can be difficult for producers who value tradition. Beef producers need to know how these costs compare with those of traditional breeding programs.

<u>Conclusion</u>

Looking at beef demand for individual beef quality grades and future implications for the beef industry suggests beef quality should be a key component of any rebuilding strategy. Even if the beef industry moves toward more ground beef production to target price conscious consumers as some industry experts may suggest, beef quality can still play an important role in satisfying consumer beef demand with restaurants such as Five Guys[®] and Smashburger creating a place for higher-quality beef in the ground beef market (Corah, 2014). However, it is important to remember that quality beef is the result of

many factors of production such as genetics, handling, nutrition, etc. Furthermore, beef quality will not magically improve overnight. In an industry with strong traditions, cattle producers can be reluctant to change. There needs to be more research into the cost efficiency of improved genetics before traditional producers will be convinced to break the mold, especially at a time when the markets are favorable for good genetics or bad. Beef production and management decisions made in the near term will determine the future success of cattle herds across the U.S. According to the results of this thesis, a beef quality focus appears to be a viable plan to rebuild the U.S. cattle inventory and sustain and build beef demand as the industry moves forward. Cow-calf producers are at the starting block, and ultimately, they are the ones who must jump on board to restructure beef production to have an increased focus on beef quality.

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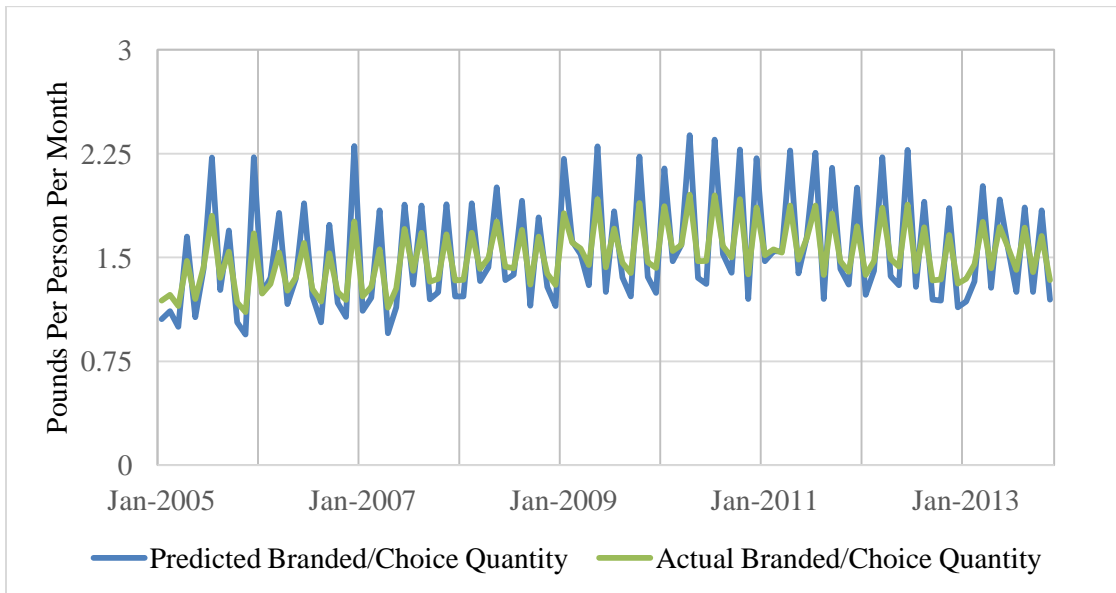
APPENDIX

Figure 9. Prime Beef Demand
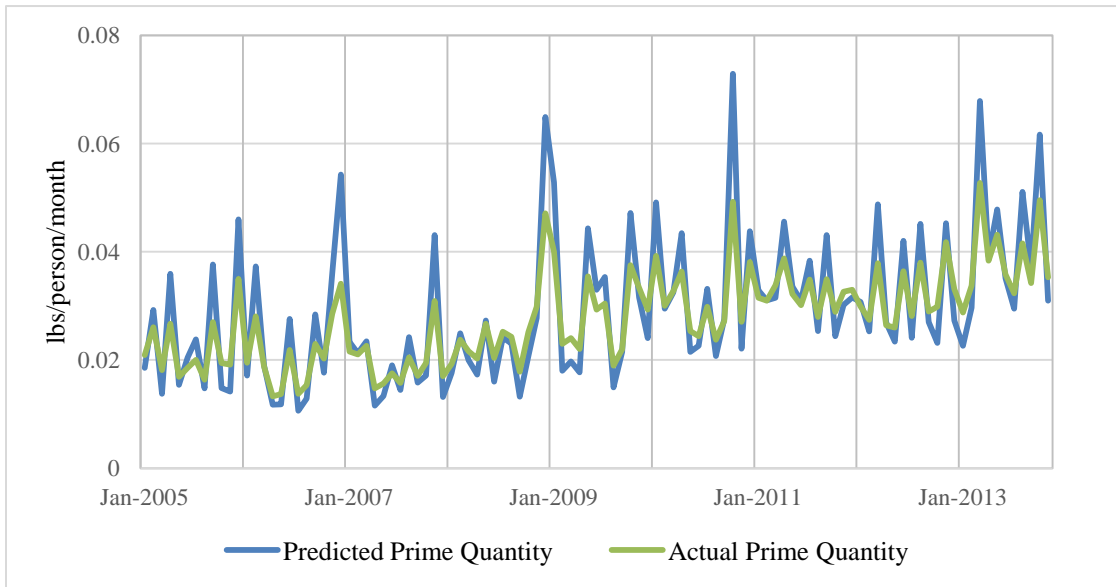
Figure 10. Branded/Choice Beef Demand

Figure 11. Select Beef Demand